# HYDROLOGY

## **Precipitation**

Though the basin has experienced periods of extreme drought and extraordinary precipitation, average annual precipitation in the Chariton River watershed ranges from 34 inches in the north to 36 inches in its southern reaches (USDA 1982).

## **USGS Gaging Stations**

There are seven active gaging stations in the Chariton River basin (Table 1). Several gaging stations have been discontinued. The gaging station near Prairie Hill is the only locality where water quality parameters continue to be monitored. Suspended solids are monitored at the Long Branch Creek station.

## **Permanence of Flow and Average Annual Discharge**

With the exception of the Chariton River, which receives discharge from Lake Rathbun and has some recharge from a large flood plain in its lower reaches, all streams within the basin experience periods of no discharge (Table 2). Intermittent flowing streams – those experiencing complete desiccation or extended periods of holding water in pool habitat only – are found primarily in streams third-order and lower (Appendix A).

## **Base and Low-flow Frequency Data**

With the exception of the lower reaches of the Chariton River, base flows are not sustained by groundwater inflow during droughts due to the low hydraulic conductivity of the basin's clay soils and underlying shales (DeTroy and Skelton 1983, Skelton 1976). This effect is intensified by highly altered stream channels and intense agricultural land use. Hence, man-made ponds and reservoirs are relied upon for water supply. A compilation of low-flow statistics for Missouri streams is contained in Skelton (1976); select data were summarized for readers who have access to this inventory only (Table 3). These data, however, must be qualified.

The regulation of streamflow by the impoundment of large reservoirs is one limitation to quantification of base-flow and low-flow statistics for streams in the Chariton River watershed (Skelton 1976, 1970). Three of the largest streams in the basin, the Chariton River, East Fork Little Chariton and Middle Fork Little Chariton, all have become regulated by reservoirs within the last 20 to 30 years. The gage records used to infer low-flow data are either outdated (i.e., pre-impoundment), or calculations are inaccurate due to inclusion of pre- and post-impoundment data. A long period of consistently regulated flows and detailed study are necessary before accurate low-flow frequency data can be calculated. However, it is possible to use drainage basin area to estimate low-flow frequency for smaller unregulated streams for which low-flow data have never been collected (Skelton 1976).

#### **Flow Duration**

These statistics are based upon measured discharge for a specified period of record and represent the flow that is exceeded for a given proportion of time. The magnitude of the ratio of the flow that is exceeded 90% of the time to the flow that is exceeded 10% of the time (90:10 ratio) can be used as an indicator of the flashiness or variability of streamflow for streams with similar drainage areas. Chariton River basin soils, landscape and channel modifications work together to create flashy flows in all basin streams (Table 4). Due to the speed that the water comes off the land, streams rise and fall quickly with each precipitation event. Additionally, perennial flow cannot be sustained even minimally because the subsurface clay soil resists water infiltration, forcing most water to run off after each precipitation event.

## **Flood Frequency**

Flood frequency data for basin streams are limited (Table 5). Multiple regression techniques revealed that drainage area and main-channel slope can be used to predict return period flows for streams that lack gage data within the plains physiographic region of Missouri (Alexander and Wilson 1995). Given that:  $Q_t$  = estimated flood discharge in cubic feet per second for a t-year recurrence interval; A = drainage area in square miles; S = main channel slope in feet per mile, the generalized least squares regression equations are as follows:

 $\begin{array}{c} Q_2 = 69.4A^{0.703}S^{0.373}\\ Q_5 = 123A^{0.690}S^{0.383}\\ Q_{10} = 170A^{0.680}S^{0.378}\\ Q_{25} = 243A^{0.668}S^{0.366}\\ Q_{50} = 305A^{0.660}S^{0.356}\\ Q_{100} = 376A^{0.652}S^{0.346}\\ Q_{500} = 569A^{0.636}S^{0.321} \end{array}$ 

## **Dam and Hydropower Influences**

The dams of large reservoirs influence three of the largest streams in the basin. Lake Rathbun is an 11,000-acre Corps of Engineers reservoir on the Chariton River in the Iowa portion of the basin. It functions primarily for flood control, and as such dampens the extremes of low and high flow. Due to the dam's presence, there can be lengthy periods of moderate flow. A minimum downstream release of 11 cubic feet per second (cfs) maintains the Chariton River as a permanent stream during periods of drought. Below the dam, Rathbun Fish Hatchery (Iowa DNR) releases a constant flow of 10 cfs, and Rathbun Regional Water withdraws between 4 and 6 cfs (P. Egeland pers. comm.). Planned discharge ranges from 800 cfs in mid summer and fall, to 1200 cfs in late summer and 1500 cfs through the winter.

The Middle Fork Little Chariton River flows into 4,950-acre Thomas Hill Reservoir north of Moberly, Missouri. The reservoir was impounded in 1965. Prior to December 1991 the reservoir covered 4,400 acres and the mean pool elevation was 710 m.s.l. Current pool elevation is 712 m.s.l. Thomas Hill Reservoir is the property of Associated Electric Cooperative, Inc.,

which uses the water for cooling its three-unit coal-fired electrical power plant. There is also a contract which allots a portion of the water to nearby municipalities. These withdrawals are not strictly monitored. To maintain downstream water quality, Associated Electric maintains a minimum downstream flow of 5 cfs, though they rarely release less than 10 cfs (J. Bindel, pers. comm.).

The East Fork Little Chariton River was dammed near Macon, Missouri by the Corps of Engineers in 1978 to form 2,430-acre Long Branch Lake. The primary project purpose is flood control. Secondarily, Long Branch Lake serves as a water supply for much of the surrounding area and provides recreation and fish and wildlife benefits. To maintain downstream water quality, the Corps of Engineers releases a minimum of 7 cfs. In extreme drought this can be reduced to 3.5 cfs (H. Diesel, pers comm.). Above an elevation of 791 m.s.l. there is uncontrolled discharge into East Fork, below this level maximum discharge varies with the surface elevation of the lake from approximately 68 cfs at 791 m.s.l. to 35 cfs at 775 m.s.l. (H. Diesel, pers. comm.).

## **Major Water Users**

Surface water withdrawals comprise the majority of public water supply in the basin (MDNR 1986). Most sources are from reservoirs of various sizes which are on small order tributary streams (MDNR unpublished). The only stream withdrawal is operated by the City of Bucklin, which uses Mussel Fork Creek as an auxiliary water supply.

Water use for irrigation is minimal throughout the basin. The only irrigated lands are in the basin's southern half; fewer than 2,500 acres are irrigated in Macon, Randolph and Chariton counties (MDNR 1986). The only major industrial use is of Thomas Hill Reservoir by Associated Electric Cooperative, Inc. Depending upon time of year and the number of units operational, AECI will use for cooling as little as 144 million gallons per day and as much as 1 billion gallons per day (B. Johnson, AECI, pers. comm.).

Table 1. Location of active and discontinued stream gaging stations within the Missouri portion of the Chariton River basin.

Gage Station Location	Type of Record	Period of Record
Chariton River @ Livonia	d	5/74-CY
Chariton River @ Novinger	d	1930-1952, 1954-CY
Chariton River @ Prairie Hill	d c	1928-CY 1962-1963, 1967-1975, 1978- 1986, 1992-CY
East Fork Little Chariton @ Macon	d	1971-CY
East Fork Little Chariton @ Huntsville	d	1962-CY
Long Branch Creek @ Atlanta CA	d	7/95-CY
Long Branch Reservoir	e	1978-CY
Middle Fork Little Chariton @ Salisbury	d c	1964-1970 1983-1986
Mussel Fork Creek @ Mussel Fork	d	1948-1951, 1962-1990
Thomas Hill Lake	e	1966-1974

Type of record: c=chemical quality, d=discharge, e=elevation. CY = Current Year (as of 1994).

Table 2. Discharge (cubic feet per second) for the period of record at gage locations within the Chariton River basin (USGS 1994).

Location	Instantaneous Peak Flow	Instantaneous Low Flow	Mean Flow	10% Exceeds	50% Exceeds	90% Exceeds	Drainage Area (Square Miles)
Chariton River Livonia, MO (1974-1994)	9200	13	697	1650	415	33	864
Chariton River Novinger, MO (1970-1994)	21500ª	11	1131	2420	589	40	1370
Chariton River Prairie Hill, MO (1929-1994)	31900	4.6 (1934)	1243	3200	350	37	1870

East Fork Little Chariton Macon, MO (1979-1994)	13900	0	92.8	284	48	5.5	112
East Fork Little Chariton Huntsville, MO (1979-1994)	10400	0	182	393	68	6.7	220
Mussel Fork Creek Mussel Fork, MO (1979-1994)	18300	0	234	517	28	0.8 <sup>b</sup>	267

<sup>&</sup>lt;sup>a</sup>- 1993 record

Table 3. Seven-day low-flow discharges at various recurrence intervals for streams in the Chariton River basin. Discharge is presented in cubic feet per second (Skelton 1976).

STREAM NAME AND LOCATION	DRAINAGE AREA	REC		ENCE INTERVAL years)		
	(square miles)	2	5	10	20	
Chariton River near Chariton, IA	182	0.6		0.2		
S. Fork Chariton River near Cambria, IA	59	<0.1		0	0	
S. Fork Chariton River near Corydon, IA	69	<0.1		0	0	
S. Fork Chariton River near Promise City, IA	168	0.3		<0.1	0	
Chariton River near Rathbun, IA <sup>1</sup>	549	1.7	0.5	0.2	0.1	
Chariton River near Centerville, IA	708	1.7		0.3		
Chariton River at Livonia, MO <sup>1</sup>	864	6.0		1.0		
Shoal Creek near Cincinnatti, IA	68	0	0	0	0	
Shoal Creek at Glendale, MO	154	0	0	0	0	
North Blackbird Creek near Unionville, MO		0	0	0	0	
Chariton River at Novinger, MO <sup>1</sup>	1,370	9.5	3.0	1.3	0.6	
Chariton River near Callao, MO <sup>1</sup>	_	22	_	6.0		

<sup>&</sup>lt;sup>b</sup>- 95% exceeds

Chariton River near Prairie Hill, MO <sup>1</sup>	1,870	24	12	8.6	6.2
Mussel Fork near Musselfork, MO	267	0.4		0	0
Mussel Fork at Keytesville, MO		0.4		0	0
E.F. Little Chariton River near Macon, MO	112	0	0	0	0
E.F. Little Chariton River near Huntsville	220	0.1		0	0

<sup>&</sup>lt;sup>1</sup>Flow partially regulated by Rathbun Reservoir since 1969. Low-flow frequency data represent natural conditions prior to regulation.

Table 4. Flow-duration discharge and 90:10 ratio for three locations in the Missouri portion of the Chariton River basin. Discharge is presented in cubic feet per second.

Stream Name and Location (assumed period of record)	Drainage Area (sq. miles)	Flow inc 95%	90:10 Ratio				
Chariton River at Novinger, MO (1931-1952, 1955- 1982)	1,370	5.4	10	38	110	2,000	1:200
Chariton River at Prairie Hill, MO (1929-1982)	1,870	17	24	80	200	2,800	1:117
East Fork Little Chariton River at Huntsville, MO (1963-1982)	220	0.3	1.2	10	28	510	1:425

Table 5. Flood discharges for 2- to 500-year intervals at selected streamflow gaging stations within the Missouri portion of the Chariton River basin (Alexander and Wilson 1995).

Stream/ Location	Period of Record (water year	Drainage Area (mi²)	Main- Channel Gradient (ft/mi)	Flood Discharge (cfs) for Indicated Recurrence Interval (years)						
	used)			2-	5-	10-	25-	50-	100-	500-
Chariton River at Novinger MO	1917, 1931- 52, 1955-69	1,370	2.63	9,590	14,700	18,100	22,300	25,200	28,100	34,400
Strop Branch near Novinger MO	1955-79	0.96	94.7	514	1,150	1,670	2,410	3,000	3,610	5,070
Chariton River at Elmer, MO	1917, 1922- 30, 1961-69	1,660	2.40	12,500	18,500	22,400	27,300	30,800	34,300	42,200
Chariton River near Prairie Hill, MO	1929- 69, 1993	1,870	2.25	13,200	18,800	22,300	26,400	29,300	32,00	38,000
Puzzle Creek near Salisbury MO	1955-79	.80	55.6	156	301	428	626	803	1,010	1,600
Mussel Fork near Musselfor k MO	1963-89	267	2.70	5,400	10,700	15,300	22,700	29,300	36,900	59,300
East Fork Little Chariton River near Huntsville MO	1963-76	220	3.50	3,360	6,950	10,400	16,200	21,800	28,600	50,700